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# **Summary of Lessons Learned from Previous PI-Led Missions: Studies and Assessments**

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Chauncey Wu and Joe McKenney  
Acquisition Managers  
Science Office for Mission Assessments (SOMA)  
NASA Langley Research Center

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## TMC Studies and Assessments

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- There are four Lessons Learned studies on the evaluation of Step 1 proposals and Step 2 CSRs that are available on the SOMA homepage. They are:
  - 1) Common Management Major Weaknesses in Step 1 Proposals
  - 2) **Summary of Lessons from Previous PI-Led Missions, April 23, 2020**
  - 3) Instrument Considerations for Step 1 and Step 2 Proposals
  - 4) Instrument Considerations for Pre-Phase A Proposals
- This presentation is an update to #2 without the Step 1 analysis and with some edits to the final charts.

**SOMA homepage - <https://soma.larc.nasa.gov/>**

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## Step 2 Lessons Learned Study Update

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### Study Questions

What is the history of TMC Risk Ratings?

Are there common causes of Major Weaknesses?

### Results

Conduct a review of formal records of approximately 1300 proposals and concept study reports retained by SOMA in the on-site archive library.

- Step 2 Major Weakness Trends and Common Causes (Step 1 results will not be presented today).

### Study Update

This update adds one new Step 2 evaluation that was completed between 2022 and 2023.

- GDC Investigation Implementation Report (IIR) / Investigation Implementation Study (IIS)



## Step 2 Common Causes of Major Weaknesses (1/4)

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Common causes of Major Weaknesses (MWs) from over 150 CSRs are summarized.

### Step 2 Technical Major Weaknesses

Issues with requirements definition and flow-down, overstated heritage, and inadequate plans for instrument and flight system verification dominate the technical category.

- **Requirements** – These weaknesses are due to problems with requirements definition, traceability and flow-down.
- **Heritage** – These weaknesses are due to issues with the implementation of heritage elements or the support of heritage claims.
  - Overstatement of the benefits of the heritage.
  - Modifications of the heritage element is required but not adequately accounted for in the proposal.
- **Verification** – These weaknesses are due to issues with inadequate plans for verification of the instrument and flight system.
  - These findings cover testing and verification during the period after the instrument and flight system each reach TRL 6, but before they are flight qualified.
  - CSRs with this weakness also often had a Major Weakness related to requirements, system complexity, or design maturity.



## Step 2 Common Causes of Major Weaknesses (2/4)

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### Step 2 Technical Major Weaknesses (continued)

- **TRLs** – These weaknesses are related to overstated TRLs or inadequate technology development plans.
  - These findings are primarily instrument related.
- **Mass Margin** – These weaknesses are issues with mass margin or contingency.
  - Mass margin Major Weaknesses still occur, but less frequently than in Step 1.
- **Thermal** – These weaknesses are due to inadequate thermal design or performance claims that are not supported.
  - These findings are primarily instrument related.
- **ADCS** – These weaknesses are issues with attitude determination and control.
  - Inadequate description of the pointing budget.
  - Mismatch between hardware capability and required performance.
- **Optics or Focal Plane** – These findings are related to the design and development of the instrument optics and focal plane.
  - Overstatement of performance is often cited.



## Step 2 Common Causes of Major Weaknesses (3/4)

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### Step 2 Management Major Weaknesses

- **Key Individuals:**
    - Lack of relevant experience among core team.
      - Some PM candidates proposed had good management credentials but limited or no history of flight project accountability.
    - Low time commitments for key members of the core team: Project Manager, Systems Engineer, Flight System Manager, Key Instrument Engineer, etc.
  - **Systems Engineering (SE):**
    - Often reflects lack of consistency among project elements.
    - Most management weaknesses since 2009 are in systems engineering.
  - **Schedule:**
    - Inadequate or inappropriately placed schedule reserve.
    - Missing key elements.
    - Inadequate definition or missing critical path.
  - **Management Plans:**
    - Key elements such as risk management are inadequate.
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## Step 2 Common Causes of Major Weaknesses (4/4)

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### Step 2 Cost Major Weaknesses

- Significant and unreconciled differences between the proposed cost and the independent cost estimate.
  - This finding is often associated with a dispute in the proposer's underlying assumptions in areas such as technical performance, TRLs, heritage, etc.
- Inadequate Basis of Estimate (BOE).
- Inadequate cost reserve.
  - No cost reserve Step 2 Major Weaknesses since 2009.
- Credibility or relevance of the supporting cost data.



## Sources of Step 2 Systems Engineering MWs in New Data

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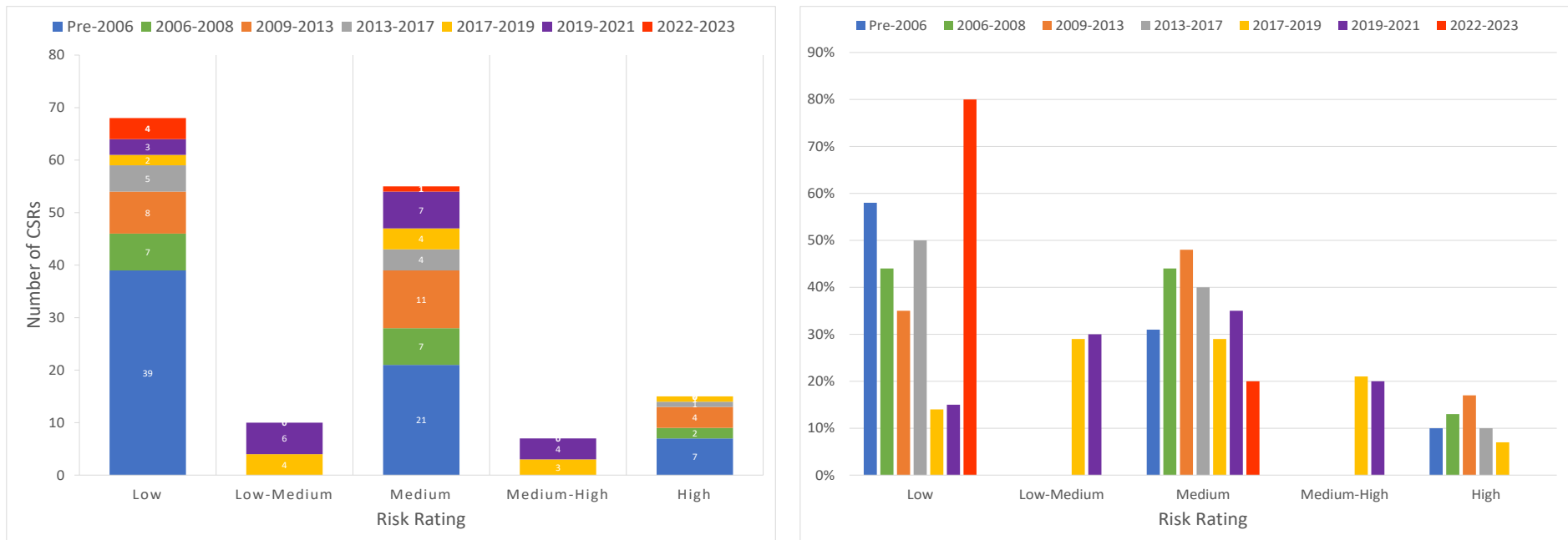
### Step 2 Systems Engineering Major Weaknesses

- The flow-down, traceability, completeness, consistency, or stability of the top-level mission or flight hardware requirements is flawed.
- The SE plans or approach, including clearly identifying the roles and responsibilities of the PSE, are flawed.





## Step 2 TMC Risk Distribution Comparison (1996-2023)

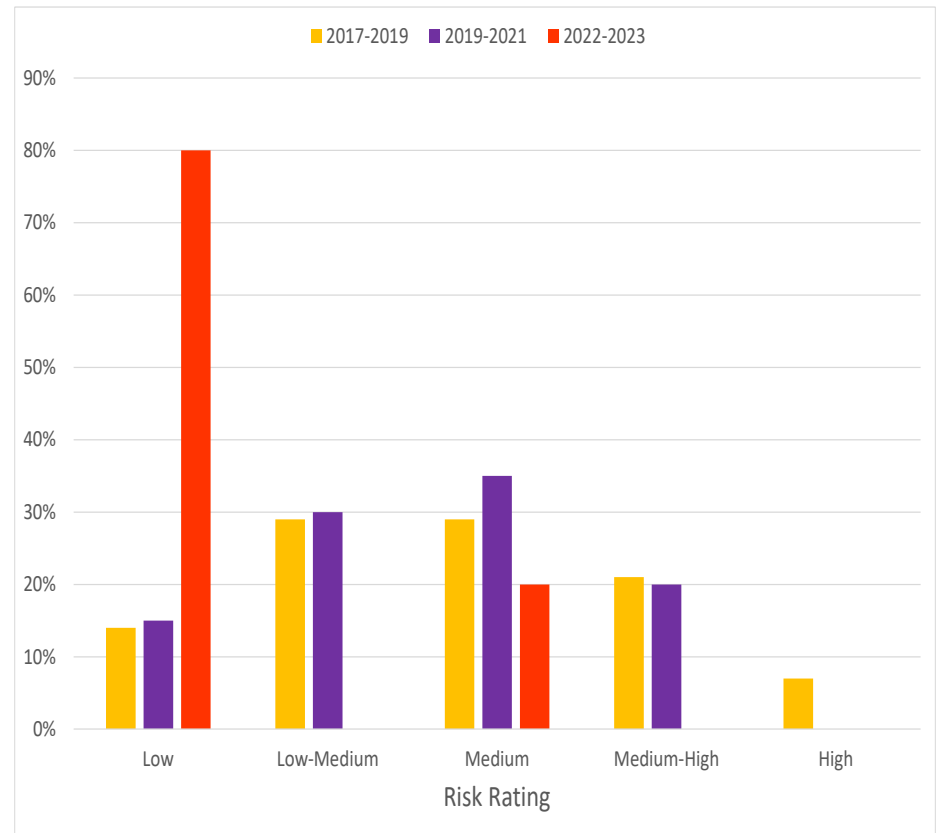
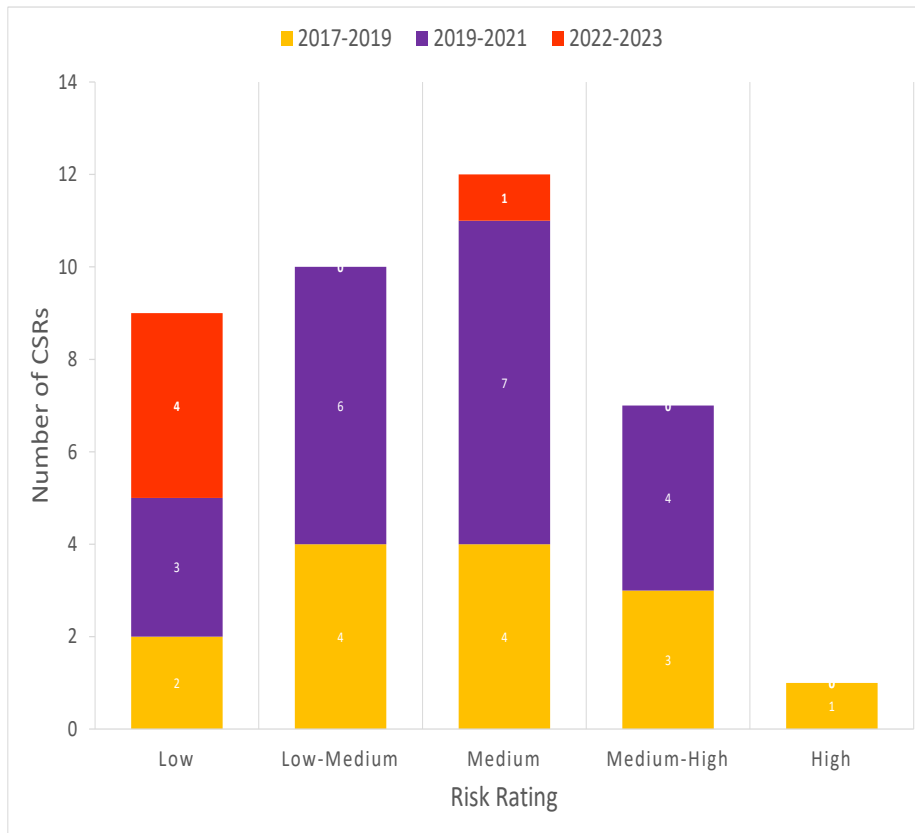


51% of all pre-2017 Step 2 CSRs are rated Low Risk, with 37% Medium Risk, and 12% High Risk.

Two additional risk ratings (Low-Medium, and Medium-High) were added for the 2017-2023 evaluations. Insufficient data is available to draw conclusions from these data, but the apparent result is the percentage of CSRs rated Low Risk has decreased. The small data set shows half of the CSRs rated as either Low or Low-Medium Risk.

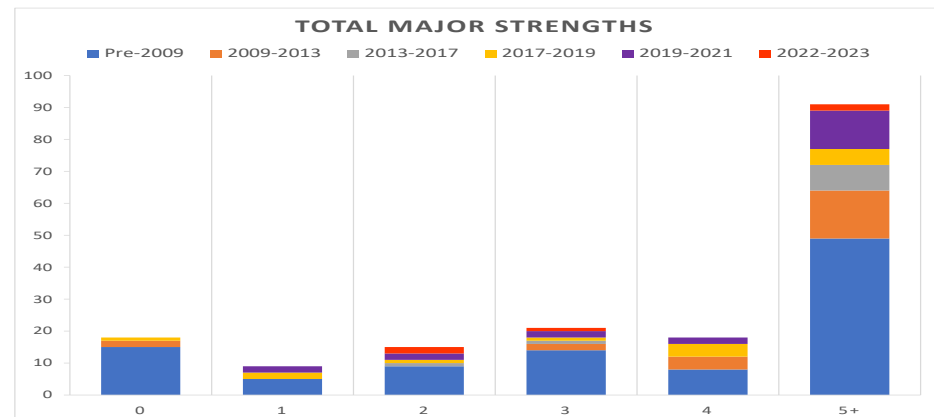
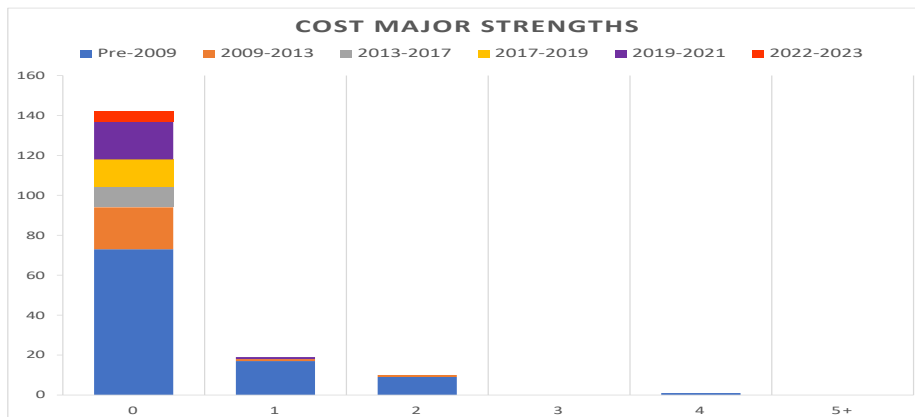
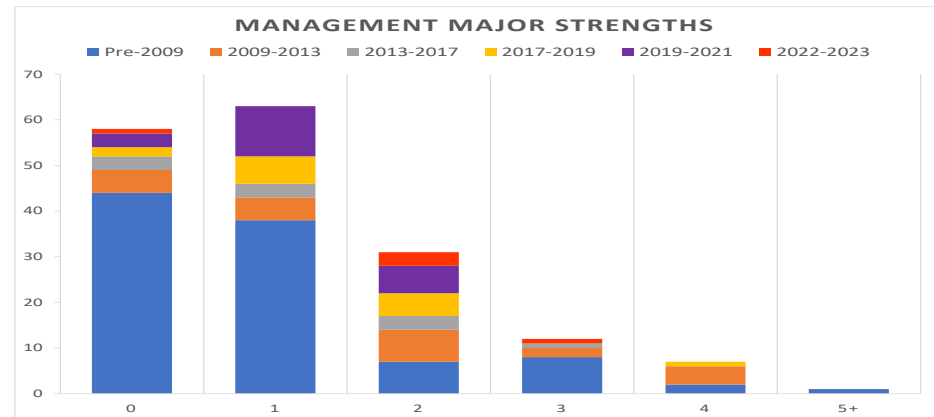
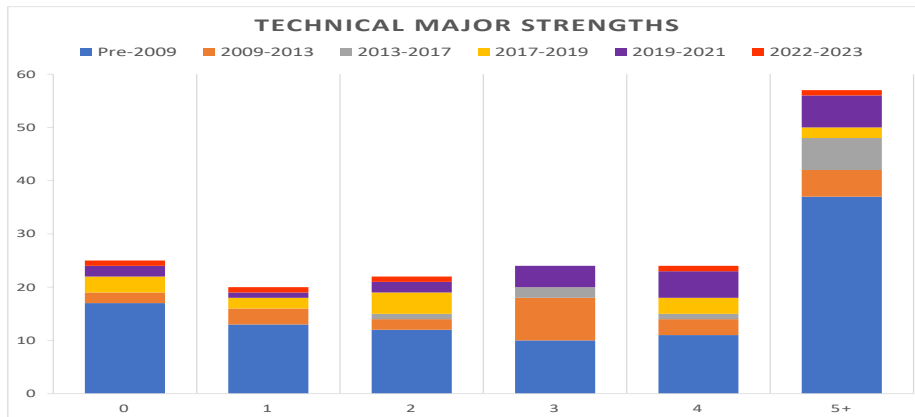


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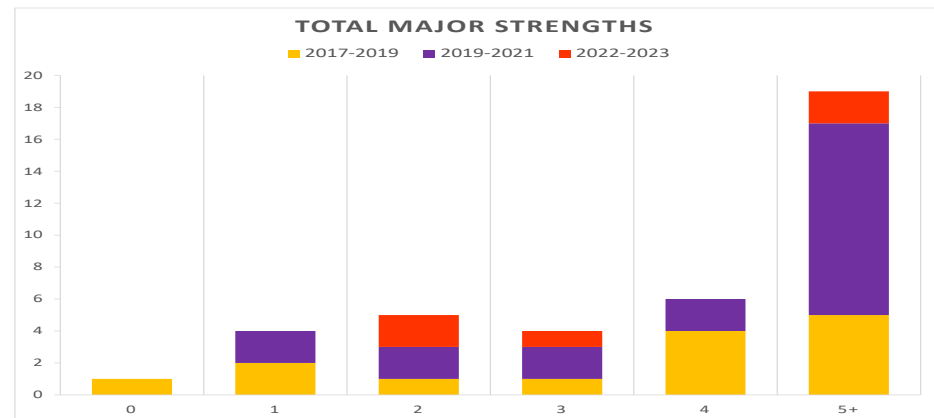
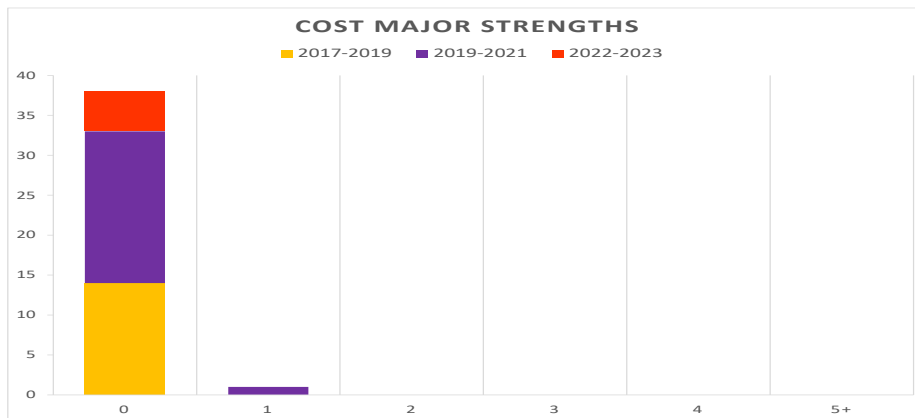
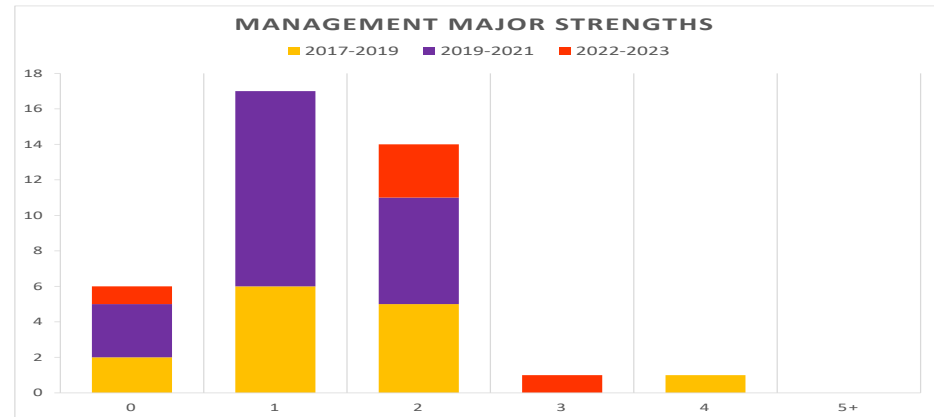
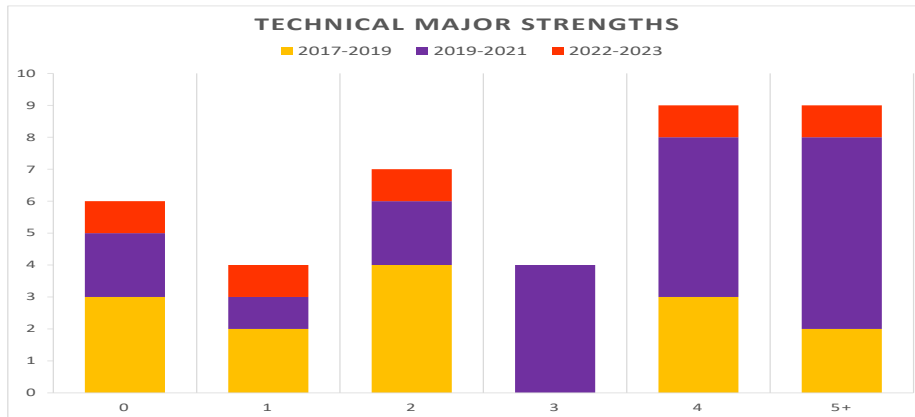


## Step 2 TMC Major Strengths (1996-2023)



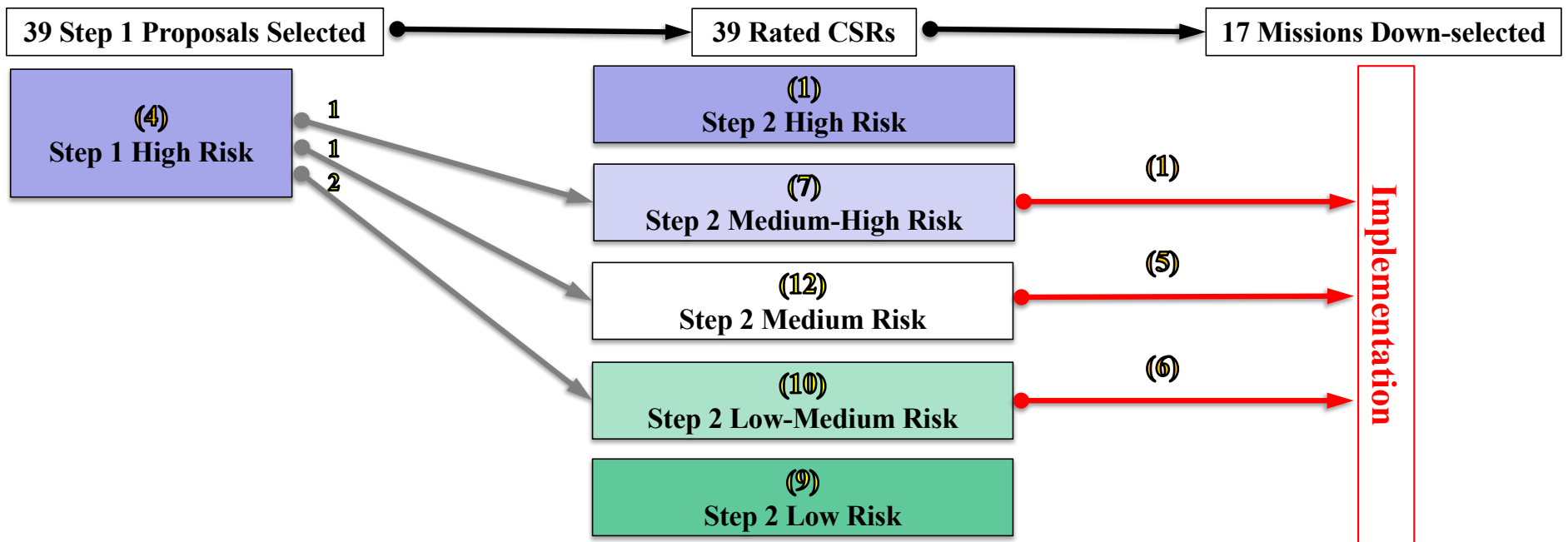


## Step 2 TMC Major Strengths (2017-2023)





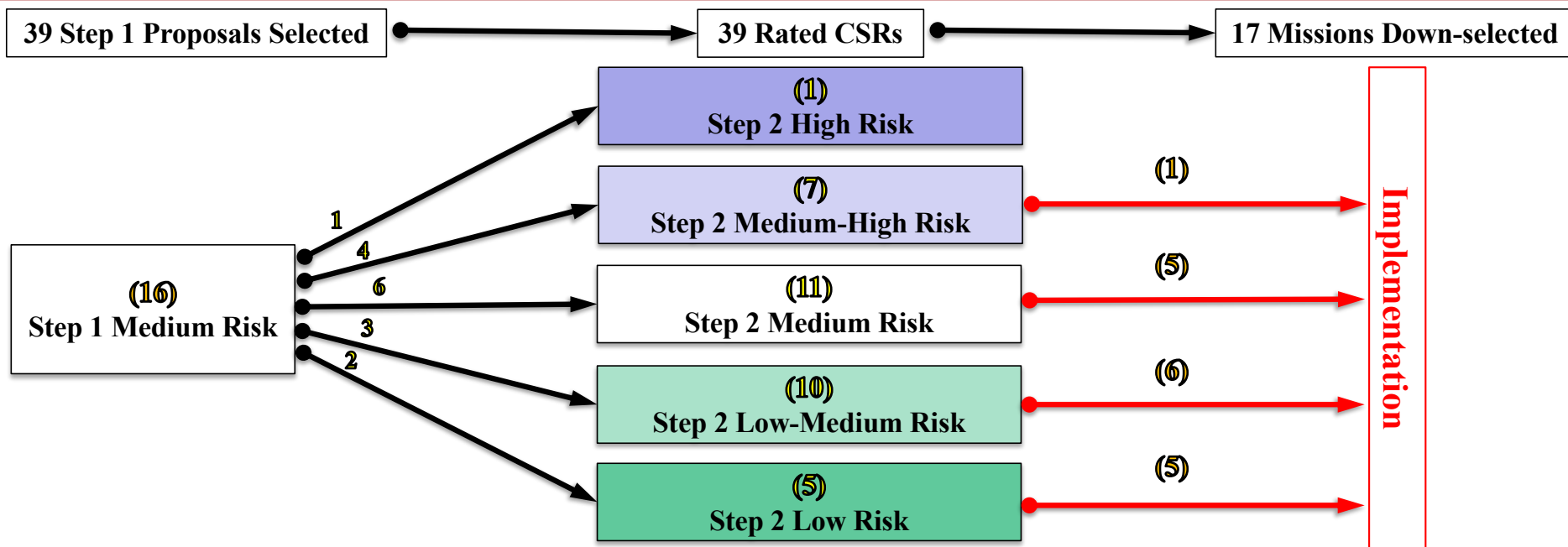
## 2017-23: Step 2 Risk Ratings of Selected Step 1 Proposals



Between 2017 and 2023 (highlighted in yellow), 19 Low, 16 Medium, and 4 High Risk proposals were selected. Of these selected proposals, 1 Medium-High, 5 Medium Risk, 6 Low-Medium Risk, and 5 Low Risk CSRs were down-selected for implementation.



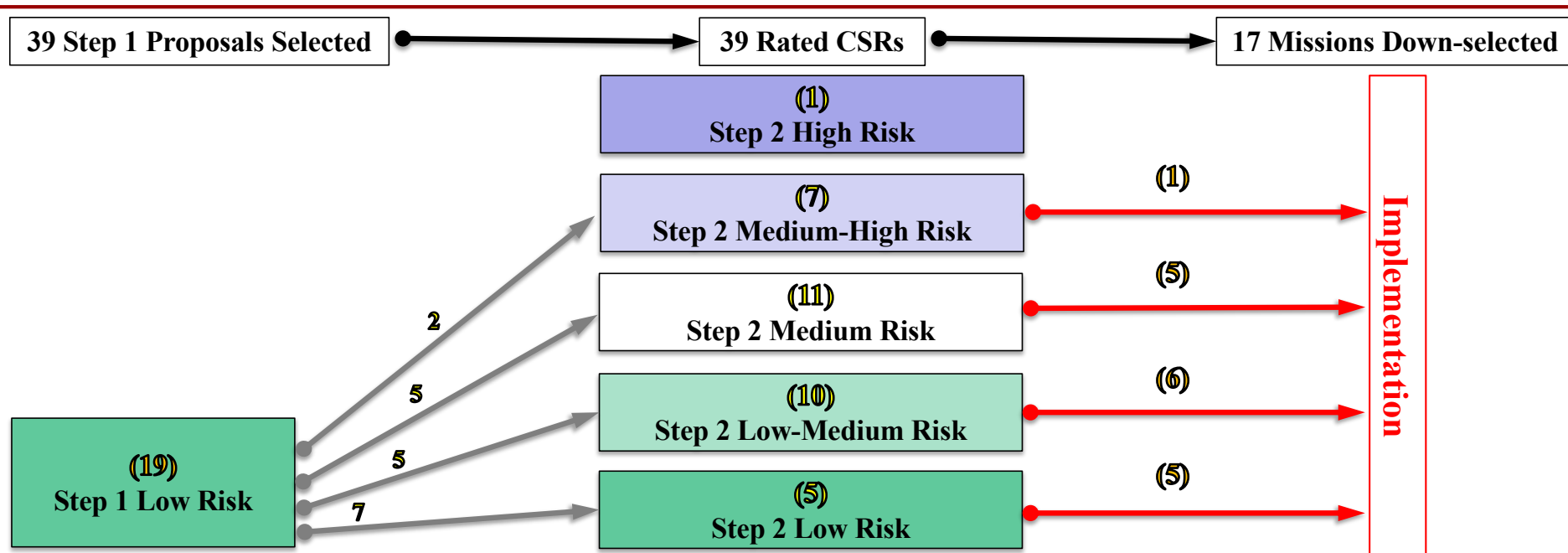
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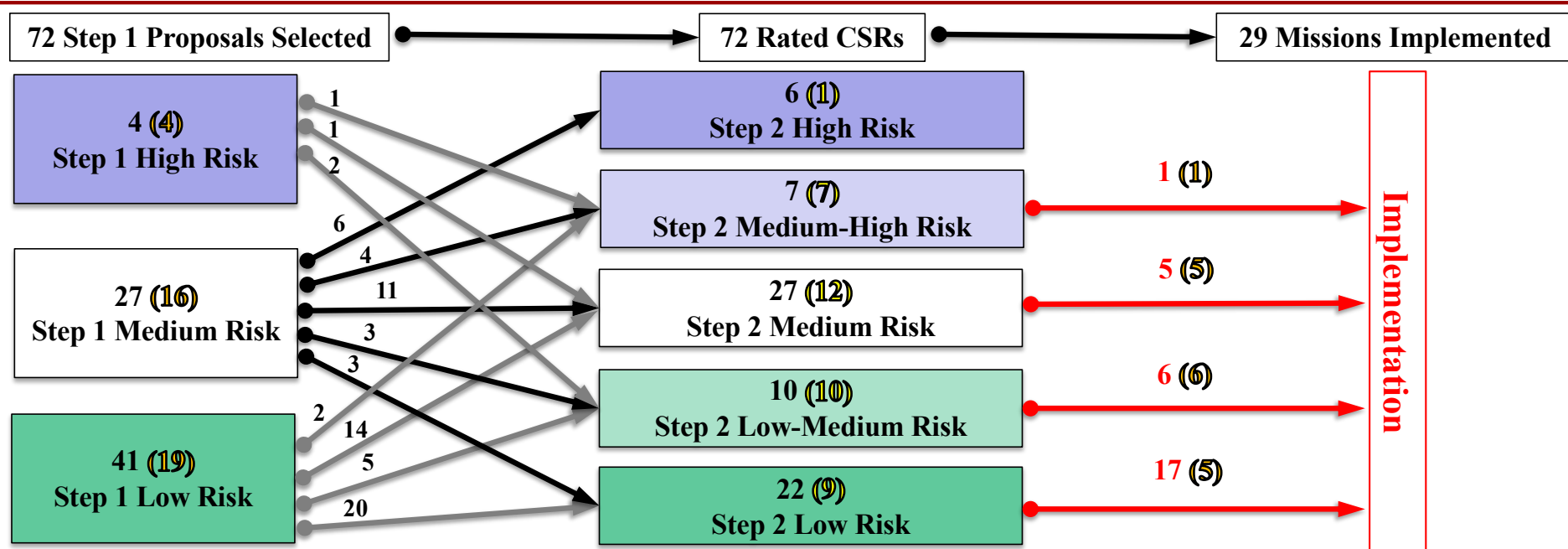
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## 2009-23: Step 2 Risk Ratings of Selected Step 1 Proposals



The risk rating for most of this small set of missions selected for Step 2 either remained the same or got worse. This result may be explained, in part, by more detailed reviews and less “benefit of the doubt” given in Step 2.

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## Step 2 TMC Summary

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SOMA has directed the evaluation of over 150 Step 2 CSRs submitted by PI-led teams since the office was formed in 1996.

**Are there common causes of Major Weaknesses in Step 2 TMC reviews? Yes!** Certain types of weaknesses persist, specifically:

- Proposed costs with their supporting BOEs could not be validated by TMC using independent cost models.
- The flow-down, traceability, completeness, consistency or stability of the top-level mission or flight hardware requirements is flawed.
- Development schedules that lack sufficient detail to verify their feasibility, have missing elements, allocate too little time for typical activities without sufficient rationale (e.g., AI&T), or have too little funded schedule reserve for the identified development risks.
- Inadequate verification plans for the instrument and flight system.
- Overstated instrument or Flight System TRLs (usually based on overstated heritage) or inadequate plans to demonstrate existing component technologies in newly integrated systems or operating in new environments.
- Inadequate margins for technical resources. Mass is the most common issue.
- Thermal design is not demonstrated to be viable.
- ADCS performance claims are not supported.
- Lack of time commitment from key management team.